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A simple design implementation of a tracking local oscillator system

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Abstract : A simple to implement, design schematic of VHF tracking local oscillator (LO) is presented in this article. The tracking LO is required in a high power transmitter system with an inbuilt automatic phase controller, where it is required to track the variable frequency RF input to produce a fixed IF. The design approach of the tracking LO sub-system has been discussed and key circuit features are described in detail. Results indicate successful implementation of the design approach.

Keywords : VHF tracking local oscillator, simple design, implementation.

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1. Introduction

In a particular application, a high power CW RF (continuous wave radio frequency) transmitter is required to incorporate ultra-stable automatic level and phase controllers [1]. One of the main design features of the proposed phase controller is the use of 455 KHz as an IF stage for generation of phase information. In such a design, if input radio frequency is allowed to vary, then the requirement of a fixed IF is met by a tracking local oscillator which follows the RF so that a fixed IF of 455 KHz is obtained. In this article, a simple and novel approach to the design implementation of a tracking local oscillator (LO) system at 35 ± 3 MHz is presented. The tracking LO is developed using the concept of two-stage mixing [2]. Two-stage mixing eliminates the need for an extremely high roll off band pass filter. Using a frequency synthesizer with high spectral purity as a part of LO system, it is ensured that the phase noise of the tracking LO follows the RF without significant degradation.

The overall system operation, design features and results are presented in the following sections.

2. System description

The block diagram of the tracking LO system is shown in Figure 1. In the present system, signal input (RF) varies by ± 3 MHz around 35 MHz. The need is to generate LO frequency being fixed at RF-455 KHz. Two oscillator modules are incorporated in the LO system. These are a 10 MHz crystal oscillator and a 9.545 MHz synthesizer having 1 KHz step size.

As shown in Figure 1, the tracking LO of frequency RF-455 KHz has been achieved with two stage frequency mixing. Initially, RF input is power divided. One output will be used as RF input for other subsystems of the high

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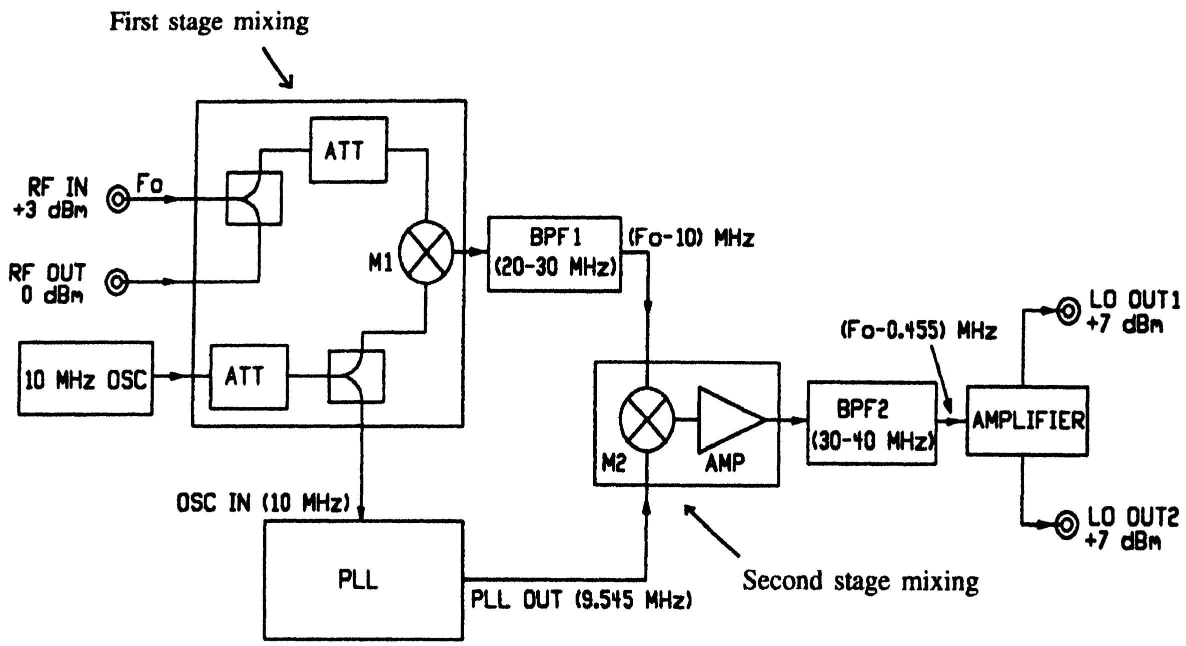

RF IN (Fo) : varies from 32 MHz to 38 MHz

Figure 1. Block diagram of tracking LO.

power transmitter. The second output will be used for the tracking LO generation. A 10 MHz highly stable crystal oscillator output is also power divided. One output will be used as a reference for 9.5454 MHz synthesizer. In the first stage mixing, the RF input is mixed with the 10 MHz reference by mixer M1 [3] to produce 25 ± 3 MHz (LSB) and 45 ± 3 MHz (USB). The lower side band is selected using a fifth order Chebysheff band pass filter BPF1 having pass band of 20–30 MHz. Simultaneously, the same 10 MHz reference is used to lock a synthesizer generating 9.545 MHz. In the second stage, the LSB is mixed with 9.545 MHz by mixer M2 [3] and filtered by another fifth order Chebysheff band pass filter BPF2 having pass band of 30–40 MHz to produce an output of 34.545 ± 3 MHz which acts as a tracking LO to the controller systems. Suitable amplification is provided in the system design to provide an output power level of +7 dBm for a RF input level of +3 dBm. For amplification purpose monolithic amplifiers MAR-4, MAR-7 [3] have been used. Provisions for two LO ports are kept so as to drive the phase and resonance frequency controllers, which are integral part of high power transmitter [1]. In the following sections, the design features of the various modules in the LO system are described. Components like mixers and amplifiers are monolithic components obtained from M/s Mini Circuits [3].

3. Design features

3.1. 10 MHz oscillator :

This oscillator is a Collpitt oscillator using a crystal to achieve highly stable output. The circuit diagram is given in Figure 2. A 15 MHz third order Elliptic low pass filter is incorporated in the output of the oscillator to suppress the harmonics and non-harmonic spurious signals. The output power level is approximately +7 dBm.

3.2. 9.545 MHz synthesizer :

This follows a standard RF synthesizer design schematic using MC145151 PLL IC. The conventional PLL design schematic is well known and is excluded from the description. The circuit diagram is shown in Figure 3. The 10 MHz crystal oscillator is used as a reference to this PLL. An active filter incorporating LM33171 operational amplifier has been used as a loop filter. The VCO module is a low-cost-simple-approach design using MAR-4, a monolithic amplifier [3] and ZC836B varactor diode [4]. The frequency tuning range of this VCO is 8.5 MHz to 11 MHz over the PLL tuning range of 0–5 V. The step size of this

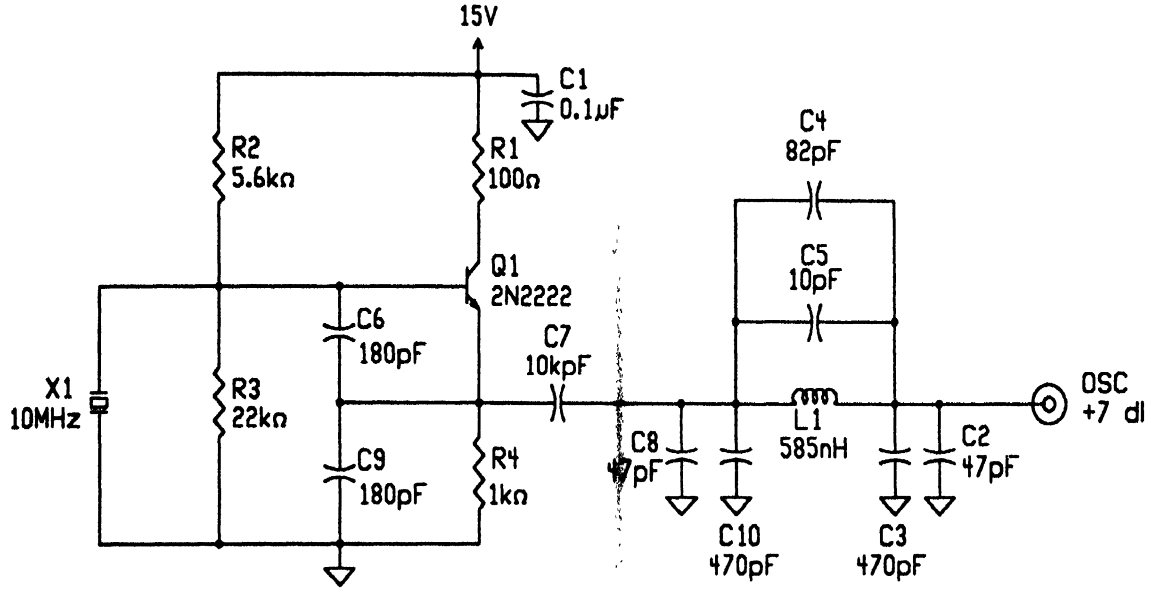

Figure 2. Circuit diagram of 10 MHz crystal oscillator.

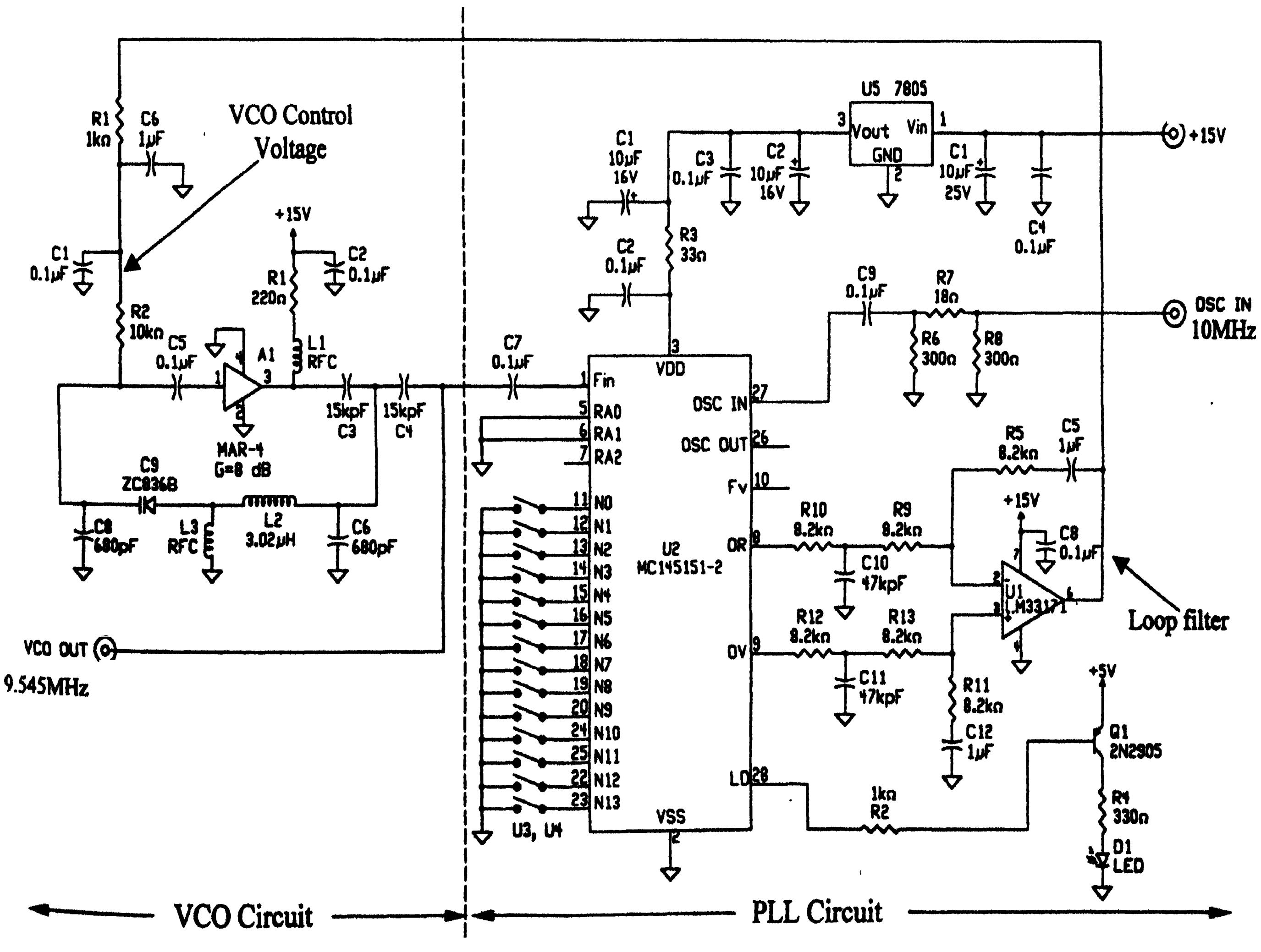

Figure 3. Circuit diagram of 9.545 MHz synthesizer.

synthesizer is 1 KHz and proper frequency is set using thumbwheel switches. The power output is + 7 dBm.

are summarized in Table 1. The loop filter cutoff frequency is chosen to be approximately 50 KHz, which is high enough as compared to phase detector frequency so as to

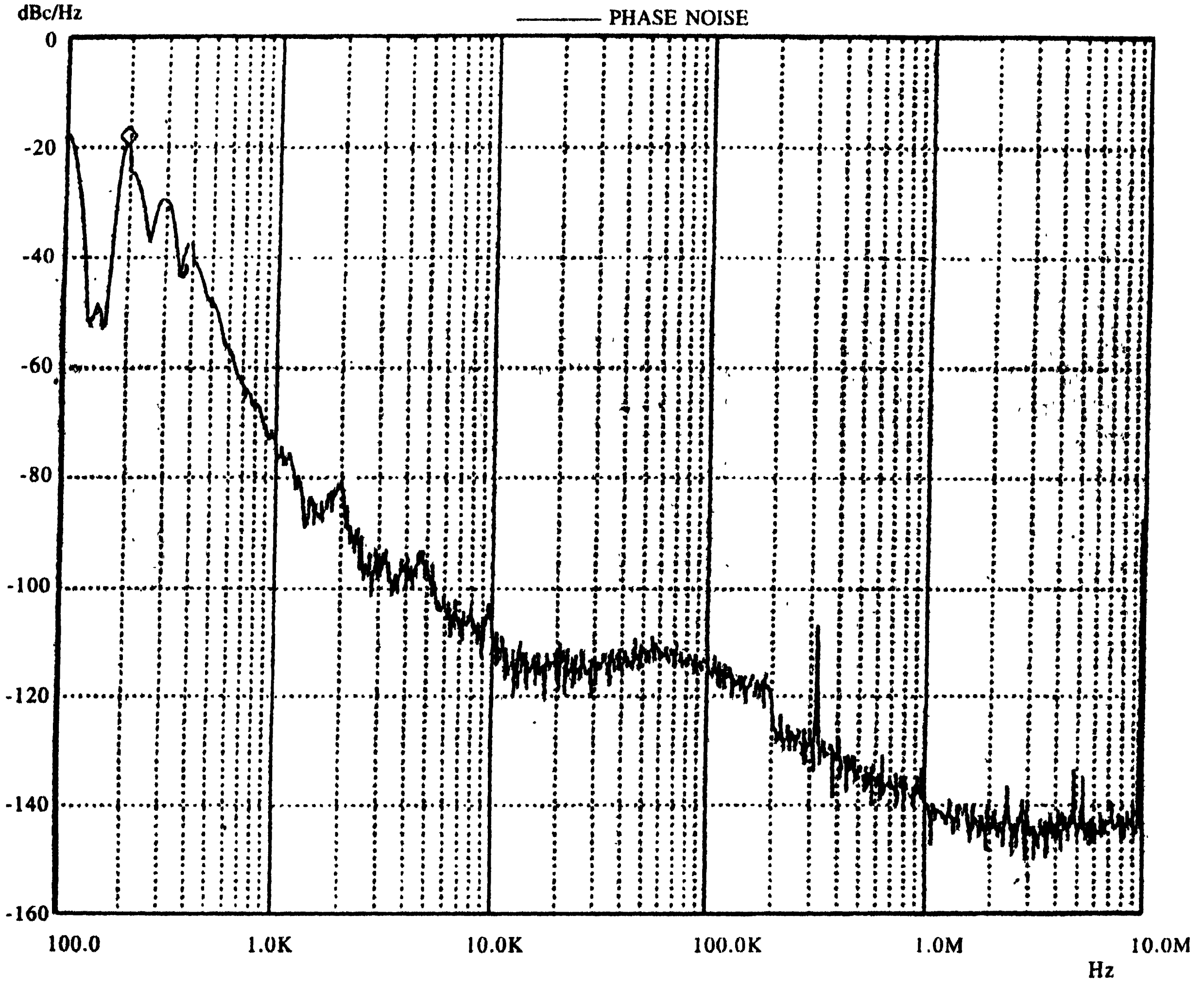

Figure 4. Phase noise characteristic of 9.545 MHZ synthesizer.

3.3. Band pass filters :

Two band pass filters using lumped components have been designed to remove the unwanted sidebands due to frequency mixing process. These filters BPF1 and BPF2 have pass band of 20–30 MHz and 30–40 MHz respectively. Fifth order Chebysheff band pass filter configuration is used to achieve sharp pass band to stop band transition.

4. Results

The above system was successfully integrated and tested. Experimental results display successful operation of the whole tracking LO system. The phase noise of 9.545 MHz synthesizer was measured on a FSEK 30 spectrum analyzer [5]. The plot is shown in Figure 4. The measured values

Table 1. Phase noise characteristic of 9.545 MHz synthesizer.

Frequency shift from carrier (Hz)	Phase noise (dBc/Hz)
100	-20
1k	-75
10k	-105
100k	-115
1M	-140
10M	-145

suppress the reference jitters. Table 1 displays the spectral purity obtained from the PLL.

5. Conclusion

A simple design approach for generating a tracking local oscillator is presented. The design approach eliminates tight tolerance requirement in specification for any subsystem. The phase noise of the LO closely follows the RF phase noise. This design has been successfully tested in an existing VHF transmitter.

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